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# ENTHALPY AND HEAT CAPACITY OF MOLYBDENUM IN THE 1200-2500°K TEMPERATURE RANGE

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This article cites the results of an experimental determination of the enthalpy of molybdenum in the 1164-2540°K range with an error of less than 1%.

The literature data [1, 3] concerning the experimental determination of the enthalpy and heat capacity of molybdenum at elevated temperatures is very scanty. Most of the data is limited to a comparatively low upper limit of 1400°K; the accuracy of determining the heat capacity is about 5%.

Our measurements were based on the method of coalescence in a high-temperature vacuum device [4, 5].

A vertical electric resistance furnace with a graphite heater surrounded by a number of coaxial screens of heat-resisting materials was used for heating the test specimens.

The temperature of the specimen was measured by an OP-48 standard optical pyrometer [6]. The corrections for absorption by the rotating prism, the vacuum window, and other parts were determined by a special calibrated temperature tube, which was installed in the furnace at the site of the ampule.

The error in the temperature measurement did not exceed 0.1-0.5% in the 1000-2500°K range.

After heating, the test-specimen ampule dropped into a receiving vessel, which was installed in the cavity of a massive block. The metallic block was contained in an air-tight vessel connected to the vacuum system of the device. The entire system from the furnace to the calorimeter (pre-evacuated) during measuring was filled by argon at a pressure of 12-14 mm Hg.

The heat-control system assured a constant temperature of the block within an accuracy of $0.002^{\circ}$.

The temperature rise of the calorimeter was measured within an accuracy of $0.001^{\circ}C$ (by a five-decade thermometric bridge and a 100-ohm platinum resistance thermometer placed on the side face of the aluminum block).

The specimens were made of molybdenum sheet 0.2 mm thick (produced by the Moscow Hard Alloys Plant). The impurity content was 0.02% (mainly molybdenum oxides), in addition to traces of nickel and silicon.

The weight of the specimens (50 g) remained constant within an accuracy of hundredths of a per cent. The surface of the ampules after the experiments was still lustrous, thus attesting to the purity of the argon in the furnace.

The heat content of the "empty" ampules was predetermined in order to exclude an error resulting from heat losses of the specimen when it is dropped into the calorimeter.

The enthalpy of the molybdenum was measured in the $1154\text{-}2462^{\circ}K$ range. The experimental data obtained, reduced to a temperature of T = 298.16 [7], are given in Table 1.

From these experimental data, which were treated by the method of least squares, we found the coefficients of the equations:

$$H_T - H_{298.16} = 4.981\ T + 8.795 \cdot 10^{-4}\ T^2 - 1460\ \text{cal/g} \cdot \text{atom} \quad (1)$$

$$C_p = 4.981 + 17.59 \cdot 10^{-4}\ T\ \text{cal/deg. g} \cdot \text{atom}, \ (1150 - 2500^{\circ}K). \quad (1a)$$

TABLE 1

| $T^o$, K | $H_T - H_{298.16}$, cal/g · atom | $T^o$, K | $H_T - H_{298.16}$, cal/g · atom | $T^o$, K | $H_T - H_{298.16}$, cal/g · atom | $T^o$, K | $H_T - H_{298.16}$ cal/g · atom |
|---|---|---|---|---|---|---|---|
| 1154 | 5509 | 1575 | 8556 | 1990 | 11917 | 2175 | 13531 |
| 1179 | 5645 | 1603 | 8789 | 2016 | 12220 | 2200 | 13817 |
| 1224 | 5998 | 1666 | 9250 | 2025 | 12262 | 2208 | 13903 |
| 1241 | 6098 | 1683 | 9365 | 2045 | 12450 | 2229 | 14081 |
| 1263 | 6266 | 1723 | 9787 | 2047 | 12501 | 2261 | 14291 |
| 1292 | 6438 | 1773 | 10151 | 2059 | 12562 | 2275 | 14368 |
| 1295 | 6504 | 1822 | 10483 | 2066 | 12570 | 2293 | 14606 |
| 1298 | 6543 | 1826 | 10499 | 2068 | 12632 | 2295 | 14584 |
| 1338 | 6717 | 1829 | 10597 | 2070 | 12665 | 2328 | 14962 |
| 1358 | 6905 | 1839 | 10624 | 2072 | 12635 | 2370 | 15275 |
| 1423 | 7424 | 1843 | 10727 | 2082 | 12694 | 2392 | 15429 |
| 1478 | 7830 | 1865 | 10900 | 2106 | 13011 | 2408 | 15548 |
| 1479 | 7810 | 1913 | 11237 | 2125 | 13183 | 2412 | 15827 |
| 1525 | 8220 | 1928 | 11495 | 2150 | 13279 | 2458 | 16041 |
| | | 1970 | 11821 | | | 2462 | 16150 |

The standard deviation of determining the coefficients of the equation is 0.4%.

The standard deviation of determining the enthalpy is between 0.3 and 1.1% in the 1000-2500°K range.

A comparison of the data we obtained for the heat content with the results of other studies is given in Table 2.

The deviation of our data from Kelley's results [2] for 1100-1300°K is 1-2%.

The value of $C_p$ in Redfield's study [1] is assumed to be constant up to 1300°K

and is about 10% lower than our data.

TABLE 2

| $T^{o}$, K | $C_p$ cal/g · atom · deg | $C_p$ cal/g · atom · deg (Kelley) | $C_p$ cal/g · atom · deg (Redfield, et al) |
|---|---|---|---|
| 1100 | 6.917 | 6.889 | 6.477 |
| 1200 | 7.093 | 7.014 | 6.477 |
| 1300 | 7.264 | 7.1397 | 6.477 |
| 1400 | 7.445 | - | - |
| 1500 | 7.620 | - | - |
| 1600 | 7.796 | - | - |
| 1700 | 7.972 | - | - |
| 1800 | 8.148 | - | - |
| 1900 | 8.324 | - | - |
| 2000 | 8.500 | - | - |
| 2100 | 8.676 | - | - |
| 2200 | 8.852 | - | - |
| 2300 | 9.028 | - | - |
| 2400 | 9.204 | - | - |
| 2500 | 9.380 | - | - |

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